

DECLARATION

I, Keiko Nakanishi, of SHIGA INTERNATIONAL PATENT OFFICE, OR Building, 23-3, Takadanobaba 3-chome, Shinjuku-ku, Tokyo, Japan, understand both English and Japanese, am the translator of the English document attached, and do hereby declare and state that the attached English document contains an accurate translation of the official certified copy of Japanese Patent Application No. 8-38048 and that all statements made herein are true to the best of my knowledge.

Declared in Tokyo, Japan

This 28th day of April, 2003

A handwritten signature in cursive script, appearing to read 'Keiko Nakanishi', written over a horizontal dashed line.

Keiko Nakanishi

[Document Type]

SPECIFICATION

[Title of the Invention] AN ANISOTROPIC TEXTILE and REPAIR AND REINFORCEMENT METHOD FOR PREEXISTING STRUCTURES USING THE SAME

[Claims]

[Claim 1]

An anisotropic textile, employing high strength and highly elastic fibers having a tensile strength of 3 GPa or more and a tensile elastic modulus of 150 GPa or more as the warp, and fibers having a tensile elastic modulus lower than that of the warp as the weft, wherein the weft threads comprise composite threads having a weight of 0.1 g or less per meter and comprising two types of fibers having a melting point difference of 50°C or more, and the spacing of the weft threads in the warp direction is within a range of 3 - 15 mm, and by means of the low melting point fibers comprising the weft, the warp and weft adhere to one another.

[Claim 2]

An anisotropic textile in accordance with claim 1, wherein the composite threads used as the weft threads comprise composite threads in which high melting point fibers having a tensile elastic modulus within a range of 50 - 100 GPa and a melting point of 200°C or more, and low melting point fibers having a tensile elastic modulus of 50 GPa or less and a melting point of 150°C or less are unified by the deposition of 0.5 - 10 weight percent of a high molecular compound which melts or softens at temperatures of 150°C or less.

[Claim 3]

A repair and reinforcement method for structures, characterized in that the anisotropic textile in accordance with claim 1 is affixed to a structure while impregnating the anisotropic textile from both sides thereof with a reactive mixture having a gelling time of 15 minutes or more at 25°C and which is capable of initiating polymerization and is sufficiently curable in 6 hours or less even at 5°C, and having as the chief components thereof a monomer having vinyl groups and an oligomer, and this is allowed to stand and cure.

[Claim 4]

A repair and reinforcement method for structures in accordance with claim 3, wherein the anisotropic textile in accordance with claim 2 is employed as the anisotropic textile.

[Claim 5]

A repair and reinforcement method for structures in accordance with claim 3, wherein the reactive mixture is an acrylic resin comprising, as main components, at least one type of (meth)acrylate monomer, and a reactive oligomer having at least 1 (meth)acrylic group within the molecule.

[Claim 6]

A repair and reinforcement method for structures in accordance with claim 3, wherein the high molecular compound to be deposited on the weft is a high molecular compound dissolved in the reactive mixture.

[Claim 7]

A repair and reinforcement method for structures in accordance with claim 3, wherein a reactive mixture containing an

organic peroxide but not containing a curing promoter is impregnated from one side of an anisotropic textile, and a reactive mixture containing a curing promoter but not containing an organic peroxide is impregnated from the opposite side.

[Claim 3]

A repair and reinforcement method for structures in accordance with claim 3, wherein a compound which is the curing promoter of the reactive mixture is deposited in advance on a warp of an anisotropic textile, and a reactive mixture which does not contain a curing promoter is employed.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a repair and reinforcement method for preexisting structures such as bridge piers, bridges, and buildings, and in particular, relates to an anisotropic textile and a repair and reinforcement method for concrete structures using the textile.

[0002]

[Prior Art]

The repair and reinforcement of preexisting structures comprising concrete such as bridge piers, bridges, and the like by the use of a unidirectional sheet material, in which carbon fibers, glass fibers, or high strength organic fibers are arranged in one direction, these are impregnated in advance with a small amount of resin, and are restricted in the weft direction and the thickness direction, or common textile materials, wherein these

are affixed to the structures while impregnating with resin, and are then left to cure, is generally known. In this case, cold-curing type epoxy resins, which have a long period of use and are comparatively easily handled, are most broadly employed as the matrix resin which is impregnated into the sheet material.

Furthermore, repair and reinforcement methods are also known in which, in order to shorten the work period at the site and to obtain stable properties, a so-called prepreg, which has been impregnated in advance with an appropriate amount of resin, is affixed, and this is then cured.

[0003]

[Problem to be Solved by the Invention]

However, the unidirectional sheet material which is generally employed in the above repair and reinforcement methods is a sheet-shaped material in which, in order to ensure good handling properties during the carrying out of repairs, slightly more resin is applied to the strengthening fibers than in the case of the level of a common sizing agent, the gaps between fibers are restricted, and they are affixed to a planar support body comprising a non-woven cloth or a net-shaped textile via adhesive layers, and this is made unitary, so that it is difficult to impregnate the resin in a short time at the site, and resin having a short period of use cannot be employed. In the case of a common textile material, when a flat support body which is made unitary through the application of a large amount of resin or an adhesive layer is used, no problems occur; however, because of the severe restriction of the space between the strengthening fibers themselves, the impregnation of

resin is not easy, and resin having a short period of use cannot be employed.

[0004]

In addition, when the cold-curing epoxy resin which is commonly employed as a matrix resin in this field is used, although this is termed a cold-curing resin, the curing properties decline markedly below 10°C and in particular below 5°C, and this leads to defects in curing. Furthermore, since the curing is hindered by the presence of moisture, there is a problem in that curing cannot be carried out during periods of rain, and this leads to a lengthening of the execution period.

[0005]

Furthermore, when sheet materials such as those described in (2) and (4) above are employed, when a resin having a low viscosity and great dissolving power such as an acrylic system monomer or unsaturated polyester resins is impregnated, the resin which is to be impregnated is impregnated while dissolving the resin which was previously deposited in order to restrict the fibers, so that the fiber orientation becomes chaotic during the execution of the procedure, and it is impossible to obtain sufficient strength. When a textile material comprising common strengthening fibers is employed, the fibers run in two directions, so that the strength in one direction is less than half, and this is extremely disadvantageous when strengthening is particularly to be carried out in one direction.

[0006]

The present invention solves the problems described in the conventional art above; it has as an object thereof to provide an anisotropic textile which has superior handling properties and resin impregnation properties, and which also generates superior strength when hardened; and to provide a repair and reinforcement method for preexisting structures which is capable of execution even in poor conditions such as low temperature or rainy conditions, and which is capable of exhibiting superior repair and reinforcement effects in a short period of time.

[0007]

[Means for Solving the Problem]

According to the present invention, the above problems are solved by an anisotropic textile, employing high strength and highly elastic fibers having a tensile strength of 3 GPa or more and a tensile elastic modulus of 150 GPa or more as the warp, and fibers having a tensile elastic modulus lower than that of the warp as the weft, wherein the weft threads comprise composite threads having a weight of 0.1 g or less per meter and comprising two types of fibers having a melting point difference of 50°C or more, and the spacing of the weft threads in the warp direction is within a range of 3 - 15 mm, and by means of the low melting point fibers comprising the weft, the warp and weft adhere to one another, and a repair and reinforcement method for preexisting structures, characterized in that the anisotropic textile is affixed to a structure while impregnating the anisotropic textile from both sides thereof with a reactive mixture having a gelling time of 15 minutes or more at 25°C and which is capable of initiating

polymerization and is sufficiently curable in 6 hours or less even at 5°C, and having as the chief components thereof a monomer having vinyl groups and oligomer, and this is allowed to stand and cure.

[0008]

[Embodiments of the Invention]

In order to effectively conduct the repair and reinforcement of preexisting structures, the use of a sheet material in which the high strength and highly elastic fibers employed are arranged in a single direction is important; however, a sheet material resulting solely from such arrangement cannot be handled, and is incapable of use as the material for repair and reinforcement. The so-called prepreg method, in which resin is impregnated in advance, is the most common method used to guarantee sufficient handling properties for use as a repair and reinforcement material; however, because the resin which cures at normal temperatures which is employed in such repair and reinforcement methods cures if it is not used immediately after impregnation, such resin is inappropriate for use as the matrix resin used in prepregs, and the common matrix resin for use in prepregs must be heated to a high temperature of over 100°C in order to be cured, so that such resin is also inappropriate for use in the repair and reinforcement method for preexisting structures. For this reason, a method is commonly employed in which the amount of resin impregnated in advance is set to the lower limit necessary to guarantee the handling properties, and moreover, a curing agent is not contained so as to guarantee the period of use, and during execution, curing is conducted using a standard temperature type curing agent

contained within a relatively large amount of resin which is additionally impregnated; however, the resin which is impregnated during execution is restricted to the same type of resin as that which was applied in advance, and it is necessary to apply a slightly greater amount than the standard amount of sizing agent in order to guarantee the handling properties during execution, so that the impregnation properties of the resin which is impregnated during execution decline dramatically. Furthermore, in order to improve the handling properties during execution, it is common to employ resin applied to the strengthening fibers, or to affix a planar support body such a non-woven cloth or a net type textile or the like via an adhesive layer which is specially provided; however, although the handling properties improve, the impregnation properties of the resin during execution decline even more.

[0009]

The anisotropic textile of the present invention does not involve the application of resin to the high strength and highly elastic fibers which are arranged in a single direction, so that there are no restrictions on the type of resin which may be impregnated during execution, and the impregnation properties are very good. In particular, resin which polymerizes and cures rapidly even at low temperatures may be employed as the matrix resin, so that there is no limitation of the environmental conditions during execution, and it is possible achieve a great shortening of the execution time. Furthermore, since this textile employs composite threads for the weft which have a lower tensile

elastic modulus than that of the warp, and after weaving, the textile is heated to a temperature above the melting point of the low melting point fibers forming the composite threads and the weft and warp are appropriately adhered, the handling properties during execution are extremely good, and problems such as a disarrangement of the orientation of the fibers during execution, and a decrease in the reinforcement effect, do not occur.

[0010]

In the present invention, it is possible to employ fibers which are commonly employed as strengthening fibers as the fibers used in the warp, so that inorganic fibers such as carbon fibers or the like, and organic fibers such as aramide fibers or the like, may be employed; however, high strength and highly elastic fibers having a tensile strength of 3 GPa or more and a tensile elastic modulus of 150 GPa or more are preferable. High strength carbon fibers having a tensile strength of 4 GPa or more are particularly preferable as they provide superior reinforcement effects.

[0011]

In the present invention, a composite thread comprising two types of fibers having a melting point difference of 50°C or more is used as the weft. The fiber with the high melting point in the composite thread is the basic weft; this functions as the weft at least until the end of execution. Accordingly, a certain amount of strength and elastic modulus is required; however, the tensile elastic modulus must be less than that of the warp. When the tensile elastic modulus is greater than that of the warp, the warp tends to drift in the longitudinal direction, and sufficient strength

is not attained. The preferred tensile elastic modulus range of the weft is 50 - 100 GPa. Furthermore, in order to prevent a disordering of the orientation of the fibers during execution, it is very important that this not dissolve in the resin which forms the matrix resin. Examples of such high melting point fibers include glass fibers; however, these fibers are not necessarily limited to this example.

[0012]

The low melting point fibers are fibers which are necessary in order to cause the warp and weft to become unitary after weaving and in order to provide superior handling properties. Without these low melting point fibers, a disordering of the fibers during handling is likely to occur, and sufficient reinforcement effects cannot be obtained. Examples of these low melting point fibers include low melting point polyamide fibers, polyester fibers, and polyolefin fibers; however, these fibers are not necessarily restricted to these examples.

[0013]

The two types of fibers described above are necessary components of the composite threads which are employed in the weft; however, in order to improve the handling properties during execution by unifying these two types of fibers and strengthening the adhesion between the warp and weft prior to the impregnation of resin, it is preferable to use composite threads to which have been applied 0.5 - 10 weight percent of a high molecular compound which melts or softens at a temperature of 100°C or less. The high molecular compound which is deposited is not particularly

restricted insofar as it is a compound which melts or softens at a temperature of 150°C or less; however, compounds which are water-soluble or are capable of forming an aqueous emulsion are preferable, since they facilitate the process of deposition onto the composite threads. Examples of such high molecular compounds include polyvinyl acetate, ethylene • vinyl acetate copolymer, vinyl acetate • acrylic copolymer, polyacrylic ester, polyester, polyethylene, and polybutadiene system copolymers; however, these compounds are not necessarily limited to the examples given.

[0014]

The low melting point fibers used in the weft of the present invention and the high molecular compound which melts or softens at temperatures of 150°C or less contribute to the superior handling properties of the anisotropic textiles; however, from the point of view of the physical properties after curing, particularly the generation of tensile strength, it is desirable that the restriction of the warp by the weft be weak. Accordingly, it is desirable to choose low melting point fibers and a high molecular compound which gradually change to a non-adhesive state as a result of the reactive mixture impregnated during execution, and to control the amount of high molecular compound deposited. In particular, it is preferable that the high molecular compound be somewhat soluble in the reactive mixture which is impregnated during execution, and it is desirable that this compound be selected in concert with the reactive mixture which is impregnated.

[0015]

Furthermore, from the point of view of providing strength after curing, it is desirable that the weft be as thin as possible, so that the weight per meter of the fiber is preferably 0.1 g or less, and more preferably within a range of 0.01 - 0.05 g.

[0016]

The preferable ratio of the high melting point fibers and the low melting point fibers in the composite threads is such that, in volumetric ratio, with respect to one unit of high melting point fibers, the low melting point fibers should be within a range of 0.25 - 2.0, and a range of 0.5 - 1.5 is more preferable from the point of view of the adhesive properties and the mechanical properties.

[0017]

The weft spacing in the anisotropic textile of the present invention is within a range of 3 - 15 mm. When the spacing is less than 3 mm, the drift of the warp in the longitudinal direction cannot be ignored, and there is a danger that the post-curing strength will decline, while when the spacing is greater than 15 mm, the handling properties of the sheet material worsen, and this is not desirable. A more preferable weft spacing range is 4 - 10 mm.

[0018]

According to the repair and reinforcement method for structures of the invention, the above anisotropic textile is affixed to a structure while impregnating the anisotropic textile from both sides thereof with a reactive mixture (a matrix resin) having a gelling time of 15 minutes or more at 25°C and which is

capable of initiating polymerization and is sufficiently curable in 6 hours or less even at 5°C, and having as the chief components thereof a monomer having vinyl groups and an oligomer, and this is allowed to stand and cure.

[0019]

Any resin may be employed as the resin which is used in combination with the anisotropic textile insofar as it obtains sufficient repair and reinforcement effects, is easily impregnated into the anisotropic textile at room temperatures, and exhibits sufficient post-curing strength; however, in order to produce sufficient repair and reinforcement effects in a comparatively short period of time without controlling the environmental conditions, it is necessary to employ a resin which initiates polymerization even at 5°C, and in which curing proceeds to a level which exhibits sufficient strength in a comparatively short period of time. It is possible to use 24 hours as a period during which curing proceeds to a level which exhibits sufficient strength; however, a period of 6 hours or less is preferable in order to efficiently conduct operations, and a period of 3 hours or less is even more preferable. On the other hand, from the point of view of facilitating the operation in which the resin is impregnated into the anisotropic textile, it is necessary that the resin which is employed have a period of use which is 10 minutes or greater, and preferably 15 minutes or greater, at room temperatures, and accordingly, the reactive mixtures described above, in which the curing reaction proceeds rapidly after the initiation of polymerization, and curing is conducted with a chain reaction type

reaction structure, are preferable. The most preferable reactive mixture is one which has a period of use of 30 minutes or more at room temperature and in which curing proceeds to a level which exhibits sufficient strength within a period of 3 hours.

[0020]

Examples of reactive mixtures satisfying such requirements include so called acrylic resins, vinyl ester resins, and unsaturated polyester resins; however, these are not necessarily restricted to these examples. Examples of particularly suitable reactive mixtures include an acrylic resin comprising, as main components, at least one type of (meth)acrylate monomer, and a reactive oligomer having at least 1 (meth)acrylic group within the molecule.

[0021]

Examples of (meth)acrylate monomers include monomers which are usually employed in acrylic resins, such as methyl (meth)acrylate, ethyl (meth)acrylate, propyl (meth)acrylate, butyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, tetrahydrofurfuryl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, (meth)acrylic acid, allyl (meth)acrylate, and the like. It is possible to employ a polyfunctional monomer with two or more (meth)acrylic groups within a molecule, such as ethylene glycol di(meth)acrylate, trimethylolpropane di(meth)acrylate, and the like. A mixture of two or more acrylic monomers may be used, if necessary.

[0022]

Examples of the reactive oligomer having a least one (meth)acrylic group within a molecule, include, in addition to the

so-called macromonomers which result from the addition of a (meth)acrylic group to the end of a comparatively low molecular weight (meth)acrylate system copolymer, styrene system copolymer, or styrene • acrylonitrile copolymer, polyester poly(meth)acrylate, which is obtained by reacting a polyprotic acid such as phthalic acid, adipic acid or the like with a polyhydric alcohol such as ethylene glycol, butanediol, or the like; a polyester poly(meth)acrylate containing allyl groups, which is obtained by the reaction of a polyprotic acid such as phthalic acid, adipic acid or the like with a polyhydric alcohol such as ethylene glycol, butanediol, or the like, and an alcohol containing allyl ether groups such as pentaerythritol triallyl ether, trimethylolpropane diallyl ether, or the like, and (meth)acrylic acid; epoxy poly(meth)acrylate obtained by reacting an epoxy resin with (meth)acrylic acid; urethane poly(meth)acrylate, which is obtained by reacting polyol, polyisocyanate, and a (meth)acrylate monomer containing a hydroxyl group; or the like; however, they are not limited to these examples.

[0023]

No particular restriction is made with respect to the curing catalyst which is used for the polymerization of such reactive mixtures, insofar as this comprises a curing catalyst system which meets the curing conditions, such as the period of use, the polymerization initiation temperature, and the curing period; catalyst systems which are commonly employed as curing catalysts for radical polymerization at room temperature may be used. Concrete examples thereof include combinations (so called redox

catalyst system) of organic peroxides such as benzoyl peroxide, methylethylketone peroxide, and the like, and metallic soaps such as cobalt naphthenate, cobalt octylate, and the like, as well as aromatic tertiary amines such as dimethylaniline, dimethyl toluidine, and the like; however, they are not limited to these examples.

[0024]

Furthermore, in order to improve various properties, it is possible to add a variety of additives, for example, reactive diluents, ultraviolet absorbers, pigments, or fillers in an amount so as not to impair the curability of resin and the mechanical properties of cured products. In particular, in order to improve air blast effects, and provide gloss to the cured surface, and in order to increase dirt resistance, the addition of paraffin wax is often preferable. According to the present invention, paraffin wax means paraffin wax, polyethylene wax, and higher fatty acids such as stearic acid, 1,2-hydroxystearic acid, and the like.

[0025]

In the repair and reinforcement method in accordance with the present invention, an anisotropic textile described above is affixed to the preexisting structure while impregnating the anisotropic textile with a reactive mixture (matrix resin), and this is allowed to stand and cure. In the repair and reinforcement method of the present invention, the execution of foundation treatment on the surface of the preexisting structure on which execution is to be conducted, prior to carrying out the repair and reinforcement, is highly desirable in order to obtain sufficient

repair and reinforcement effects. This foundation treatment may be conducted by means of a method in which initially, where coating or the like has been carried out on the surface of the structure, this is removed, and the surface is rendered smooth, whereupon cracked portions are filled in with a material having good adhesion properties with the reactive mixture which is employed in the present invention, and where necessary, this is subjected to further abrasion, and the surface is rendered smooth.

[0026]

Representative embodied configurations of the repair and reinforcement method of the present invention are given below.

(Embodied Configuration 1)

A reactive mixture in which a curing catalyst system is uniformly mixed is first applied to those portions on which repair and reinforcement is to be carried out, and after an anisotropic textile has been applied, the same reactive mixture is impregnated from the opposite side, and allowed to cure.

[0027]

(Embodied Configuration 2)

A reactive mixture (liquid A) containing an organic peroxide but not containing a curing promoter is first applied to the preexisting structure, and then an anisotropic textile is affixed thereto, whereupon a reactive mixture (liquid B) containing a curing promoter but not containing an organic peroxide is impregnated from the opposite side, and by means of the contact and mixture of both, curing is carried out. The adoption of such a method is particularly desirable when a sufficient reactive

mixture period of use is to be guaranteed. Liquid A and liquid B may of course be used in reverse order.

[0028]

(Embodied Configuration 3)

A compound which is the curing promoter of the reactive mixture may be deposited in advance on the strengthening fibers, which is a warp of an anisotropic textile, and during execution, a reactive mixture which does not contain a curing promoter may be impregnated from both sides, and by means of the contact and mixture with the curing promoter, initiating polymerization, and this may then be allowed to cure.

[0029]

[Examples]

Embodiments

Hereinbelow, the present invention will be discussed in greater detail using embodiments.

[0030]

(Embodiment 1)

Glass fibers (having a tensile elastic modulus of 72.5 GPa, a melting point of 840°C, and a specific gravity of 2.54 g/cm³) having a TEX number of 22.5 (0.0225 g/m) were twisted together with low melting point polyamide multifilaments (having a melting point of 125°C and a specific gravity of 1.08 g/cm³) having a total denier of 70 deniers, and this was twisted together with an ethylene vinyl acetate copolymer (having a melting point of 80°C), and a composite thread on which 1.5 g thereof was deposited per 1000 m of thread, which served as the weft, was obtained. The weight per meter of

this composite thread was approximately 0.03 g, and the ratio of the high melting point fibers and the low melting point fibers was 1:0.8 in volumetric ratio.

[0031]

Pyrofill TR30G carbon fibers (having a tensile strength of 4.5 GPa, a tensile elastic modulus of 235 GPa, and a filament count of 12000) produced by Mitsubishi Rayon (Corporation) were arranged so as to reach 300 g/m², and this was used as the warp, while the composite thread described above was used as the weft, weaving was accomplished so that the weft spacing was 5 mm, and an anisotropic textile was obtained. Furthermore, by passing this textile through a pair of rollers heated to 180°C, the anisotropic textile of the present invention, in which the warp and weft partially adhered to one another, was obtained. The anisotropic textile which was obtained was flexible and extremely easy to handle, since somewhat rough handling thereof did not cause disordering of the fibers or breakdown of the weave.

[0032]

70 parts of methyl methacrylate, two parts of 1,3-butylene glycol dimethacrylate, 25 parts of butyl acrylate macromonomer having a number-average molecular weight of 6,000 and having a methacrylic group on the terminus thereof, one part of n-paraffin, and 1 part of γ -methacryloxypropyl trimethoxysilane were sufficiently mixed so as to be uniform, and then finally one part of N,N-dimethyl-p-toluidine was added and mixed, and this produced the reactive mixture containing no organic peroxide.

[0033]

Two parts of benzoyl peroxide was added to 100 parts of the reactive mixture described above, and this was impregnated into two of the above anisotropic textiles so that the resin weight reached approximately 1000 g/m², and this was allowed to stand for one hour at a standard temperature, and cured. A tension test piece was produced from the composite obtained, and was evaluated. When converted to a fiber content ratio of 100% (dividing by the theoretical thickness of the anisotropic textile), the tensile strength was 390 kgf/mm², and it was thus confirmed that sufficient strength was present. Furthermore, the impregnation properties of the resin were extremely good.

[0034]

(Embodiment 2)

Two parts of benzoyl peroxide were added to 100 parts of the reactive mixture of embodiment 1, and this was applied in an amount of 250 g/m² to the surface of a concrete bending test piece to which the anisotropic sheet was to be applied, and an anisotropic textile identical to that of embodiment 1 was affixed thereto, and thereafter, the reactive mixture was applied to amount of 250 g/m², this was impregnated into the anisotropic textile, and was allowed to stand. The gelling time at the standard temperature of the reactive mixture was approximately 25 minutes; however, since the anisotropic textile was easy to handle and the impregnation of the reactive mixture was also extremely good, the operation proceeded smoothly, and it was a simple matter to conduct the operation of affixing the textile to six test spots in the space of a few minutes. The curing was completed in a period of approximately 1 hour from

the admixture of an organic peroxide, and the adhesion to the concrete after a period of one hour and a half was evaluated using a building type tension test in conformity with JIS A6909. Breakage occurred at the concrete portions, so that it was determined that sufficient adhesive strength was obtained. Next, a bending test was executed, and the reinforcement effects were confirmed. The results of a bending test without reinforcement were 90 kgf/cm², while the results when reinforcement was conducted were 160 kgf/cm².

[0035]

(Embodiment 3)

Test pieces were produced and evaluated in the same manner as in embodiment 2, with the exception that the operation in which the textile was affixed to the concrete test piece was conducted at 5°C. Even at 5°C, curing was sufficient after 2 hours, and in the adhesion test, breakage occurred at the concrete portion. Furthermore, the bending strength increased, at 155 kgf/cm², and sufficient reinforcement effects were thus confirmed even as a result of execution at low temperatures.

[0036]

(Embodiments 4 - 16, Comparative Examples 1 - 6)

Test pieces made of concrete and reinforced by anisotropic textiles were produced and evaluated in the same manner as those of embodiment 1, with the exception that the composition of the composite thread used as the weft, and the spacing of the weft in the anisotropic textile, differed. The composition of the anisotropic textiles and the results of the evaluations are shown

in tables 1 and 2. The abbreviations and references in the tables are as given below.

[0037]

CF: Pyrofill TR30G carbon fibers produced by Mitsubishi Rayon (Corporation)

The numbers in the tables refer to the CF weight of the anisotropic textile.

GF: glass fibers (having a tensile elastic modulus of 72.5 GPa, a melting point of 840°C and a specific gravity of 2.54 g/cm³)

PA: low melting point polyamide multifilaments (having a melting point of 125°C and a specific gravity of 1.08 g/cm³)

PE: low melting point polyester multifilaments (having a melting point of 130°C and a specific gravity of g/cm³)

PO: low melting point polyolefin multifilaments (having a melting point of 100°C and a specific gravity of g/cm³)

The number shown under headings GF - PO in the tables indicate the weights per unit length of each fiber used in the weft of the anisotropic textile.

EV: ethylene vinyl acetate copolymer (having a melting point of 80°C)

AC: acrylic system copolymer (having a melting point of 75°C)

The numerals in the table refer to the weight percent of high molecular compound in the composite thread.

Handling properties, impregnation properties of the resin: Double circle... extremely good, Circle... good, Triangle... somewhat poor, and X... poor

Tensile strength: shown in units of kgf/mm

[0038]

[Table 1]

Anisotropic Textile Composition		Embodiment 4	Embodiment 5	Embodiment 6	Comparative Example 1	Embodiment 7	Embodiment 8
warp	CF g/m ²	300	300	300	300	300	300
weft (B)	(A) CF g/m	0.0112	0.0375	0.0675	0.135	0.0225	0.0225
	PA g/m	0.0078	0.0078	0.0078	0.0078	0.0033	0.0056
	PE g/m	-	-	-	-	-	-
	PO g/m	-	-	-	-	-	-
(A) : (B)		1:1.6	1:0.54	1:0.27	1:0.14	1:0.34	1:0.59
High Molecular Compound							
Spacing	EV wt%	5	5	5	5	5	5
	AC wt%	-	-	-	-	-	-
	mm	5	5	5	5	5	5
Characteristics							
handling properties		◎	◎	○	△	○	◎
Resin Impregnation Properties		◎	◎	◎	◎	◎	◎
Tensile Strength		400	385	370	325	375	395

Anisotropic Textile Composition		Embodiment 9	Comparative Example 2	Embodiment 10	Embodiment 11	Comparative Example 3
warp	CF	g/m ²	300	300	300	300
	(A) GF	g/m	0.0225	0.0225	0.0225	0.0225
	PA	g/m	0.0111	0.0078	0.0078	0.0078
	PE	g/m	-	-	-	-
	PO	g/m	-	-	-	-
weft	(A) : (B)		1:1.16	1:0.81	1:0.81	1:0.81
	High Molecular Compound		1:3.48			
	EV	wt%	5	1	7	15
	AC	wt%	-	-	-	-
	Spacing	mm	5	5	5	5
Characteristics						
handling properties		◎	◎	○	◎	◎
Resin Impregnation Properties		◎	△	◎	◎	×
Tensile Strength		385	350	395	390	315

[0039]

[Table 2]

		Comparative Example 4	Embodiment 12	Embodiment 13	Comparative Example 5
Anisotropic Textile Composition					
warp	CF g/m ²	300	300	300	300
	(A) GF g/m	0.0225	0.0225	0.0225	0.0225
weft	PA g/m	0.0078	0.0078	0.0078	0.0078
	PE g/m	-	-	-	-
	PO g/m	-	-	-	-
	(A) : (B)	1:0.81	1:0.81	1:0.81	1:0.81
High Molecular Compound					
	EV wt%	5	5	5	5
	AC wt%	-	-	-	-
Spacing mm		1	3	10	20
Characteristics					
handling properties		◎	◎	◎	×
Resin Impregnation Properties		×	○	◎	◎
Tensile Strength		310	380	385	385

			Embodiment 14	Embodiment 15	Embodiment 16	Comparative Example 6
Anisotropic Textile Composition						
warp	CF	g/m ²	300	300	300	300
	(A) GF	g/m	0.0225	0.0225	0.0675	0.1012
weft (B)	PA	g/m	-	-	0.0222	0.0333
	PE	g/m	0.0078	-	-	-
	PO	g/m	-	0.0078	-	-
	(A) : (B)		1:0.81	1:0.81	1:0.77	1:0.77
High Molecular Compound						
EV	wt%		-	-	5	5
	AC	wt%	5	5	-	-
Spacing		mm	5	5	5	5
Characteristics						
handling properties			◎	◎	◎	◎
Resin Impregnation Properties			◎	◎	○	◎
Tensile Strength			390	395	370	336

[0040]

(Embodiment 17)

70 parts of methyl methacrylate, two parts of 1,3-butylene glycol dimethacrylate, 25 parts n-butyl acrylate macromonomer having a number average molecular weight of 6,000 and having a methacrylic group on the terminus thereof, one part of n-paraffin, and one part of γ -methacryloxypropyl trimethoxysilane were sufficiently mixed so as to be uniform, and then two parts of N,N-dimethyl-p-toluidine were added, and the reactive mixture containing no organic peroxides was obtained.

[0041]

Furthermore, a reactive mixture B containing organic peroxides and containing no curing promoter was obtained by adding four parts of benzoyl peroxide in place of the two parts of N,N-dimethyl-p-toluidine described above.

[0042]

The reactive mixture A described above was applied to the surface of a concrete bending test piece to which the anisotropic sheet was to be applied so as to reach a level of 250 g/m², and after an anisotropic textile identical to that of embodiment 1 was affixed thereto, reactive mixture B was applied from the opposite side in an amount of 250 g/m², and this impregnated into the anisotropic textile and was allowed to stand. Reactive mixture A and reactive mixture B were both stable at standard temperatures in isolation; however, after mixing, a reaction rapidly proceeded, and gelling occurred after approximately 30 minutes. Since both reactive mixtures A and B impregnated into the anisotropic textile

extremely well, the operation preceded smoothly, and it was possible to complete the affixing of the textile to six test pieces in a few minutes. The curing was completed in approximately one hour after the impregnation of reactive mixture B, and when a building type test of the adhesion with the concrete was conducted after a period of one and a half hours, the breakage occurred at the concrete portions, so that it was confirmed that sufficient adhesive strength was obtained. Next, a bending test was conducted, and the reinforcement effects were confirmed. The bending strength when reinforcement was not carried out was 90 kgf/cm², whereas the bending strength when reinforcement was carried out was 150 kgf/cm².

[0043]

(Embodiment 18)

10 parts of N,N-dimethyl-p-toluidine and 20 parts of n-butyl acrylate macromonomer having a number average molecular weight of 6,000 were dissolved in 70 parts methylethylketone, and this was uniformly mixed. By means of treating an anisotropic textile identical to that of embodiment 1 with this mixture, an anisotropic textile was prepared on which was deposited, per square meter, 5 g of N,N-dimethyl-p-toluidine and 10 g of n-butyl acrylate macromonomer having a number average molecular weight of 6,000.

[0044]

70 parts per weight of methyl methacrylate, 2 parts per weight of 1,3-butylene glycol dimethacrylate, 23 parts of n-butyl acrylate macromonomer having a number average molecular weight of 6,000 and having a methacrylate group on the terminus thereof, one

part of n-paraffin, and one part of α -methacryloxypropyl trimethoxysilane were mixed sufficiently so as to become uniform, and then two parts of benzoyl peroxide were added, and thus a reactive mixture containing an organic peroxide but not containing a curing promoter was prepared.

[0045]

The reactive mixture not containing a curing promoter described above was applied to the surface of a concrete bending test piece to which the anisotropic sheet was to be applied, in an amount of 250 g/m², and then the anisotropic textile described above, on which N,N-dimethyl-p-toluidine was deposited, was affixed, and then the reactive mixture described above was again applied from the opposite side in an amount of 250 g/m², and this was allowed to impregnate into the anisotropic textile and was allowed to stand. The anisotropic textile described above was extremely easy to handle and the impregnation of the reactive mixture was also extremely good, so that the operation proceeded smoothly, and it was possible to affix the textile to 6 test pieces in the space of a few minutes. The curing was conducted in approximately 1 hour from the impregnation of the reactive mixture described above, and when a building type test of the adhesion with the concrete was conducted after a period of one and half hours, the breakage occurred at the concrete portions, so that it was determined that sufficient adhesive strength was obtained. Next, a bending test was carried out. As a result of the reinforcement, the bending strength increased to 165 kgf/cm.

[0046]

(Embodiment 19)

Concrete bending test pieces were produced and evaluated which were reinforced with anisotropic textiles identical to those of embodiment 2, with the exception that, in place of the n-butyl acrylate macromonomer, a polyester methacrylate containing allyl ether groups, which was produced by reacting phthalic acid, ethylene glycol, pentaerythritol triallylether, and methacrylic acid, was employed, and one part cobalt naphthenate was used as a curing promoter. The gelling time at standard temperatures was approximately 30 minutes, and no problems were presented by the affixing operation of the anisotropic textile. Furthermore, the bending strength of the test pieces reinforced with this anisotropic textile was 160 kgf/cm², and it was thus confirmed that sufficient reinforcement effects were obtained.

[0047]

(Embodiment 20)

Concrete bending test pieces were produced and evaluated which were reinforced with anisotropic textiles identical to those of embodiment 19, with the exception that, in place of the polyester methacrylate containing allyl ether groups, an epoxy methacrylate, which was obtained by reacting an epoxy resin containing 190 g/eq. of epoxy with methacrylic acid, was employed.

The gelling time at standard temperatures was approximately 30 minutes, so that the affixing operation of the anisotropic textile presented no difficulties. Furthermore, the bending strength of the test pieces reinforced with this anisotropic

textile was 155 kgf/cm², and it was thus confirmed that sufficient reinforcement effects were obtained.

[0048]

[Effects of the Invention]

The anisotropic textile of the present invention has superior handling properties and resin impregnation properties, and generates superior strength when cured. In addition, the repair and reinforcement method for structures using the anisotropic textile of the present invention is capable of execution even in poor conditions such as low temperature or rainy conditions, and which is capable of exhibiting superior repair and reinforcement effects in a short period of time.

[Document Type]

ABSTRACT

[Abstract]

[Problem to be Solved by the Invention]

To provide an anisotropic textile which has superior handling properties and resin impregnation properties, and which also generates superior strength when hardened; and to provide a repair and reinforcement method for preexisting structures which is capable of execution even in poor conditions such as low temperature or rainy conditions, and which is capable of exhibiting superior repair and reinforcement effects in a short period of time.

[Means for Solving the Problem]

An anisotropic textile, employing high strength and highly elastic fibers having a tensile strength of 3 GPa or more and a tensile elastic modulus of 150 GPa or more as the warp, and fibers having a tensile elastic modulus lower than that of the warp as the weft, wherein the weft threads comprise composite threads having a weight of 0.1 g or less per meter and comprising two types of fibers having a melting point difference of 50°C or more, and the spacing of the weft threads in the warp direction is within a range of 3 - 15 mm, and by means of the low melting point fibers comprising the weft, the warp and weft adhere to one another.

[Elected Drawing] None